A1.0 INTRODUCTION

A1.1 REGULATORY HISTORY

A detailed discussion of the regulatory history of the RMI Titanium Company (RMI) Sodium Plant was provided in the Executive Summary and Section 1.0 of the draft final Corrective Measures Study (CMS) report. As discussed in these sections of the draft final CMS report, the RMI Sodium Plant received a final RCRA hazardous waste management operating permit from the USEPA Region 5 in 1987, which required RMI to conduct a RCRA Facility Investigation (RFI). The following documents have been generated as a result of this requirement and have lead to the preparation of the draft final CMS report:

- Draft final RFI Report (included Health and Environmental Assessment (HEA)) (May 1989)
- Revised RFI Report (June 1990)
- Draft final CMS - Partial Submittal (included HEA-removed from RFI report per USEPA) (June 1990)
- Draft final Supplemental Investigation Report (April 1991)
- Draft final CMS Plan (May 1991)
- Revised Supplemental Investigation Report (August 1991)
- Revised CMS Plan (August 1991)
- Draft final CMS Report (August 1991)
- Revised CMS Plan (March 1993)
- Draft Final CMS Report (March 1993)

As shown above, the HEA was originally submitted to the USEPA in the draft final RFI report (May, 1989). On the recommendation of the USEPA, the HEA was removed from the RFI report and inserted in the draft final CMS report (as revised to reflect USEPA comments on the RFI).

The HEA process, as described in the current RFI guidance (USEPA, 1989), is intended to be an expedited exposure assessment. Basically, the HEA process consists of two components: (1) the identification of potential receptors and likely exposure routes; and (2) the comparison of measured (or in some cases, predicted)

constituent concentrations in various media developed in the release characterization of the RFI to chronic exposure limit criteria. It is this level of detail that is reflected in the HEA provided in the draft final CMS report.

In June 13, 1994 comments from the USEPA on the draft final CMS report (see Attachment I), the USEPA expressed the desire for a full quantitative human health risk assessment to be performed for soils at the RMI Sodium Plant. The details of this assessment were confirmed at a July 28, 1994 meeting between USEPA, RMI, and ECKENFELDER INC.

A1.2 GUIDANCE CONSULTED

The risk assessment presented here is for baseline (i.e., no action) conditions. Consistent with the USEPA comments on the draft final CMS, the risk assessment was developed based primarily on guidance set forth in the following documents:

- *Risk Assessment Guidance for Superfund--Volume I, Human Health Evaluation Manual (Part A)* (USEPA, 1989a)
- *Exposure Factors Handbook* (USEPA, 1989b)
- *Dermal Exposure Assessment: Principles and Applications* (USEPA, 1992b)

The following guidance documents were also consulted:

- *Interim Final RCRA Facility Investigation (RFI) Guidance* (USEPA, 1989)
- *Human Health Evaluation Manual Supplemental Guidance: "Standard Default Exposure Factors"* (USEPA, 1991a)

A1.3 REPORT ORGANIZATION

This risk assessment is organized into the following sections:

A1.0 Introduction
A2.0 Exposure Assessment

A3.0 Toxicity Assessment

A4.0 Risk Characterization

A5.0 References

This risk assessment provides potential risk estimates using the most recent USEPA guidance. This assessment should not be used outside the stated context; it should not be used to represent actual risks to human receptors at or near the site. Furthermore, the assumptions made in this risk assessment typically have a conservative (i.e., err on the protective side) bias.

A2.0 EXPOSURE ASSESSMENT

This section presents the components of potential human exposure pathways. In the risk assessment process, only "complete" pathways may be quantified. An exposure pathway may be viewed as complete if it consists of four elements: (1) a source and mechanism of release to the environment; (2) an environmental transport medium (e.g., air, water, etc.); (3) a point of potential contact between a receptor and the environmental medium (referred to as exposure concentrations); and (4) an exposure route (e.g., inhalation, ingestion, etc.) at the exposure point. The exposure pathway evaluation is accomplished by describing actual or potential exposure scenarios which involve the above elements.

In this section, the media and constituents of interest will be presented, as well as the calculation of exposure point concentrations, the evaluation of exposure scenarios, and the quantification of potential exposures.

As discussed on page 1-16 of Section 1.5 of the draft final CMS report (ECKENFELDER INC., 1993), the specific areas and constituents specified in the CMS Plan to be addressed in the CMS, based on the comparison of site soil concentrations to USEPA action levels (see Table 3-1 of the draft final CMS report), were as follows:

Area B:	Cadmium, lead, and arsenic in surficial soils
Area C:	Lead and arsenic in surficial soils
Area D:	Lead in shallow soils 3 to 6.5 feet deep
Area F:	Lead and arsenic in surficial soils
Area G:	Arsenic and lead in surficial soils; cadmium and lead in soils 0.5 to 3.3 feet deep

Only these specific areas and constituents are of interest for the risk assessment. It should be noted that there is a discrepancy between the areas constituents and soil depths of interest shown above and those specified in the USEPA's June 13, 1994 comment letter on the draft final CMS report, which called for a full quantitative human health risk assessment of soils (see Attachment I and Section A1.0). In this letter from the USEPA, page 2-15 of the draft final CMS report (which presents

constituents and soil depths by area that were shown to be above background soil levels) was referenced for defining the areas and soil depths of interest for the risk assessment. This discrepancy was resolved, with the USEPA expressing concurrence that the areas, constituents, and soil depths listed above (i.e., those listed on page 1-16 of the draft final CMS report) should be those of interest for the risk assessment for the RMI Sodium Plant (Personal Communication, 1994).

As further discussed in Section A4.4, although arsenic is listed as a constituent of interest, there is no plant-related source of arsenic at the RMI Sodium Plant. However, there are believed to be numerous potential offsite sources. RMI expressed this concern to the USEPA at the July 28, 1994 meeting, but the USEPA requested that arsenic remain a constituent of interest and be evaluated in the baseline risk assessment.

Table A2-1 presents site soils data for the five areas (B, C, D, F, and G) and three constituents (arsenic, cadmium, and lead) of interest listed above, along with site-specific background soil concentrations. Data for Areas B and C combined are also presented together in Table A2-1 since these areas were evaluated together in the draft final CMS report. In Table A2-1, each sample concentration is presented in both the log-transformed and untransformed format. Data were log-transformed in order to calculate 95th percent upper confidence limit (UCL) exposure concentrations. According to USEPA's risk assessment guidance (USEPA, 1992a), soil sampling data are generally considered to be lognormally distributed; therefore, the potential exposure concentrations should be calculated using the arithmetic mean of log-transformed data for a given constituent, as shown below:

$$UCL = e^{\left(\bar{x} + 0.5s^2 + \frac{sH}{\sqrt{n-1}}\right)}$$

where:

UCL = 95th percent upper confidence limit on the arithmetic mean

e = natural log

$\bar{x}$ = the mean of the log-transformed data

TABLE A2-1

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREA B

	Concentration (mg/kg)								
	SS3-1 0-4 in.	SS3-2 0-4 in.	SS3-3 0-4 in.	SS3-4 0-4 in.	SB-12 0.8-1.5 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)									
Arsenic	13.6	23.6	12.8	23.5	16.8	18.1	12.8	23.6[c]	5
Cadmium	46.5	18.2	731	1.35	<1.0[b]	160	1.35	731[c]	5
Lead	141	99.2	1140	41.5	<15.0	287	41.5	1,140[c]	5

	Concentration (mg/kg)								
	SS3-1 0-4 in.	SS3-2 0-4 in.	SS3-3 0-4 in.	SS3-4 0-4 in.	SB-12 0.8-1.5 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)									
Arsenic	2.610	3.161	2.549	3.157	2.821	2.860	0.291	2.384	25.8
Cadmium	3.839	2.901	6.594	0.300	0.000	2.727	2.718	12.673	1.86×10^{10}
Lead	4.949	4.597	7.039	3.726	2.708	4.604	1.613	7.631	1.73×10^{5}

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREA C

	Concentration (mg/kg)								
	SS2-1 0-4 in.	SS2-2 0-4 in.	SS2-3 0-4 in.	SS2-4 0-4 in.	SB-11 1.4-1.8 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)									
Arsenic	23.4	21.6	18.9	23.0	22.2	21.8	18.9	23.4[c]	5
Lead	83.4	15.3	209	<15.0	<15.0	67.5	15.3	209[c]	5

	Concentration (mg/kg)								
	SS2-1 0-4 in.	SS2-2 0-4 in.	SS2-3 0-4 in.	SS2-4 0-4 in.	SB-11 1.4-1.8 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)									
Arsenic	3.153	3.073	2.939	3.135	3.100	3.080	0.085	2.035	23.8
Lead	4.424	2.728	5.342	2.708	2.708	3.582	1.231	5.918	2,930

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREAS B AND C COMBINED

	Concentration (mg/kg)													
	SS3-1 0-4 in.	SS3-2 0-4 in.	SS3-3 0-4 in.	SS3-4 0-4 in.	SB-12 0.8-1.5 ft.	SS2-1 0-4 in.	SS2-2 0-4 in.	SS2-3 0-4 in.	SS2-4 0-4 in.	SB-11 1.4-1.8 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)														
Arsenic	13.6	23.6	12.8	23.5	16.8	23.4	21.6	18.9	23.0	22.2	19.9	12.8	23.6	10
Cadmium	46.5	18.2	731	1.35	<1.0	--[e]	--[e]	--[e]	--[e]	--[e]	160	1.35	731[c]	5
Lead	141	99.2	1140	41.5	<15.0	83.4	15.3	209	<15.0	<15.0	177	15.3	1,140[c]	10

	Concentration (mg/kg)													
	SS3-1 0-4 in.	SS3-2 0-4 in.	SS3-3 0-4 in.	SS3-4 0-4 in.	SB-12 0.8-1.5 ft.	SS2-1 0-4 in.	SS2-2 0-4 in.	SS2-3 0-4 in.	SS2-4 0-4 in.	SB-11 1.4-1.8 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)														
Arsenic	2.610	3.161	2.549	3.157	2.821	3.153	3.073	2.939	3.135	3.100	2.970	0.233	1.913	23.2
Cadmium	3.839	2.901	6.594	0.300	0.000	--[e]	--[e]	--[e]	--[e]	--[e]	2.727	2.718	12.673	1.86×10^{10}
Lead	4.949	4.597	7.039	3.726	2.708	4.424	2.728	5.342	2.708	2.708	4.093	1.456	4.107	1,270

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREA D

	Concentration (mg/kg)					
	6S 3.0 ft.	5D 6-6.5 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)						
Lead	59.8	<15.0	37.4	59.8	59.8	2

	Concentration (mg/kg)					
	6S 3.0 ft.	5D 6-6.5 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)						
Lead	4.091	2.708	3.400	0.978	--[f]	--[f]

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREA F

	Concentration (mg/kg)								
	SS4-1 0-4 in.	SS4-2 0-4 in.	SS4-3 0-4 in.	SS4-4 0-4 in.	SB-15 0.5-1.3 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)									
Arsenic	13.1	23.0	18.0	16.4	17.1	17.5	13.1	23.0	5
Lead	62.5	93.9	152	41.5	<15.0	73.0	41.5	152[c]	5

	Concentration (mg/kg)								
	SS4-1 0-4 in.	SS4-2 0-4 in.	SS4-3 0-4 in.	SS4-4 0-4 in.	SB-15 0.5-1.3 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)									
Arsenic	2.573	3.135	2.890	2.797	2.839	2.847	0.202	2.202	22.0
Lead	4.135	4.542	5.024	3.726	2.708	4.027	0.881	4.399	573

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

AREA G

	Concentration (mg/kg)										
	SS5-1 0-4 in.	SS5-2 0-4 in.	SS5-3 0-4 in.	SS5-4 0-4 in.	8S 0.7-2.0 ft.	SB-16 0.5-3.0 ft.	SB-17 1.6-3.3 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)											
Arsenic	22.4	10.0	18.3	23.5	--[e]	--[e]	--[e]	18.6	10.0	23.5[c]	4
Cadmium	--[e]	--[e]	--[e]	--[e]	16.5	173	66.1	85.2	16.5	173[c]	3
Lead	33.7	31.1	25.8	25.8	59.8	195	315	98.0	25.8	315[c]	7

	Concentration (mg/kg)										
	SS5-1 0-4 in.	SS5-2 0-4 in.	SS5-3 0-4 in.	SS5-4 0-4 in.	8S 0.7-2.0 ft.	SB-16 0.5-3.0 ft.	SB-17 1.6-3.3 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)											
Arsenic	3.109	2.303	2.907	3.157	--[e]	--[e]	--[e]	2.869	0.393	3.147	38.8
Cadmium	--[e]	--[e]	--[e]	--[e]	2.803	5.153	4.191	4.049	1.181	15.425	4.55×10^7
Lead	3.517	3.437	3.250	3.250	4.091	5.273	5.753	4.082	1.027	3.777	489

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

BACKGROUND

	Concentration (mg/kg)											
	SSB-1 0-4 in.	SSB-2 0-4 in.	SSB-3 0-4 in.	SSB-4 0-4 in.	SSB-5 0-4 in.	SSB-6 0-4 in.	SSB-7 0-4 in.	SSB-8 0-4 in.	SSB-9 0-4 in.	SSB-10 0-4 in.	SSB-11 0-4 in.	SSB-12 0-4 in.
(untransformed data)												
Arsenic	16.1	14.7	17.0	11.5	15.9	10.8	8.3	13.1	10.9	<5.0	8.8	12.0
Cadmium	<1.0	<1.0	5.46	<1.0	<1.0	41.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead	20.6	20.6	31.1	25.8	60.5	16.6	<15.0	<15.0	16.6	36.1	<15.0	26.4

	Concentration (mg/kg)												
	9S 10.0 ft.	9D 4.8-5 ft.	9D 19-19.5 ft.	9D 56.5-5.7 ft.	10S 1.6-2.6' ft.	10S 9.7 ft.	10S 14.5-15 ft.	11D 1-2.5 ft.	11D 10.7-10.9 ft.	Arith. Average	Minimum Detected	Maximum Detected	n
(untransformed data)													
Arsenic	17.6	19.8	17.4	16.4	17.5	18.4	20.0	31.1	13.5	15.0	8.3	31.1	21
Cadmium	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.1	5.46	41.6	21
Lead	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0	59.8	<15.0	22.8	16.6	60.5	21

TABLE A2-1 (Continued)

SUMMARY OF UNTRANSFORMED AND LOG-TRANSFORMED DATA BY AREA FOR CONSTITUENTS OF INTEREST IN SITE SOILS[a]

RMI SODIUM PLANT
ASTABULA, OHIO

BACKGROUND

	Concentration (mg/kg)											
	SSB-1 0-4 in.	SSB-2 0-4 in.	SSB-3 0-4 in.	SSB-4 0-4 in.	SSB-5 0-4 in.	SSB-6 0-4 in.	SSB-7 0-4 in.	SSB-8 0-4 in.	SSB-9 0-4 in.	SSB-10 0-4 in.	SSB-11 0-4 in.	SSB-12 0-4 in.
(log-transformed data)												
Arsenic	2.779	2.688	2.833	2.442	2.766	2.380	2.116	2.573	2.389	1.609	2.175	2.485
Cadmium	0.000	0.000	1.697	0.000	0.000	3.728	0.000	0.000	0.000	0.000	0.000	0.000
Lead	3.025	3.025	3.437	3.250	4.103	2.809	2.708	2.708	2.809	3.586	2.708	3.273

	Concentration (mg/kg)												
	9S 10.0 ft.	9D 4.8-5 ft.	9D 19-19.5 ft.	9D 56.5-5.7 ft.	10S 1.6-2.6 ft.	10S 9.7 ft.	10S 14.5-15 ft.	11D 1-2.5 ft.	11D 10.7-10.9 ft.	Arith. Average	Standard Deviation	H Value	95th UCL[d]
(log-transformed data)													
Arsenic	2.868	2.986	2.856	2.797	2.862	2.912	2.996	3.437	2.603	2.645	0.384	1.893	17.8
Cadmium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.258	0.877	2.403	3.05
Lead	2.708	2.708	2.708	2.708	2.708	2.708	2.708	4.091	2.708	3.009	0.452	1.949	27.3

[a]Only the areas and constituents of interest resulting from the comparison of data to background and USEPA action levels from the draft final CMS report are given (see Section A2.0).
[b]Concentrations reported below method detection limit (BMDL) were assumed to be equal to the detection limit and are shown with a less than (<) symbol.
[c]The 95th UCL exceeded the maximum detected value. The maximum detected value was used to calculate the risk.
[d]95th UCL is the upper 95th percent confidence limit on the arithmetic average (i.e., the anti-log of the log-transformed UCLs).
[e]Dashes (--) indicate that the constituent is not of interest in that Area or at that depth.
[f]An H value could not be calculated for Area D (and therefore, also the 95th UCL) due to the small number of samples associated with this area.

s = the standard deviation of the log-transformed data

n = sample size

H = statistic (interpolated from "Tables of Confidence Limits for Linear Functions of the Normal Mean and Variance" (Land, 1975)

Consistent with the USEPA comments, for each area of interest, soil sample concentrations were averaged together for the depths of interest. For example, in Area B, cadmium, lead, and arsenic were of interest in surficial soils only. Therefore, all surficial soils for Area B (5 samples) were averaged together to calculate the UCLs. In order to calculate the UCLs as shown above, it was necessary to calculate the arithmetic mean and the standard deviation of the log-transformed data. These values are provided in Table A2-1. Also presented in Table A2-1 are H values. H values were interpolated from "Tables of Confidence Limits for Linear Functions of the Normal Mean and Variance" (Land, 1975). Once calculated, the UCL for each constituent was compared to the maximum detected concentration of the constituent within the appropriate area. Per USEPA guidance (USEPA, 1989a), if the UCL was less than the maximum concentration, it was used as the potential exposure concentration; if the UCL was greater than the maximum concentration, then the maximum concentration was used as the potential exposure concentration. The potential exposure concentrations are used for the calculation of risks as discussed later in Section A4.0.

A2.1 IDENTIFICATION OF POTENTIAL RECEPTORS AND CURRENT AND FUTURE EXPOSURE SCENARIOS

In this section, current and potential future land use are briefly described in order to evaluate potential human receptors which may be exposed to site constituents. Land use and demography information pertinent to the RMI Sodium Plant was presented in Section 4.6 of the RFI report (ECKENFELDER INC., 1990). The potential current and future receptor populations and exposure routes are also generally discussed. The quantification of potential exposure routes and the discussion of specific exposure parameters will be given in Section A2.2.

A2.1.1 Current Scenario

As discussed in Section 4.6.2 of the RFI report, the RMI Sodium Plant is located in a highly industrialized area of Ashtabula County. Only about 4 percent of the county is classified as residential, with the major residential areas being located along Lake Erie in the areas of Ashtabula City, Kingsville, and Conneaut City. Within a three mile radius of the RMI Sodium Plant, land use is primarily "unclassified", which includes vacant land (55 percent) and farmland (21 percent) (see Table 4-17 of the RFI report).

The locations of the residences nearest the RMI Sodium Plant are shown in Figure 2-1 of the draft final CMS report. There were only four residences identified in the immediate vicinity of the RMI Plant: two located approximately 1,000 feet west of the RMI plant entrance, one located approximately 500 feet west of the northwestern RMI property boundary, and one located approximately 2,500 feet from the southwestern property boundary.

Access to the RMI plant property is restricted. A chainlink fence surrounds the entire property boundary, and access to the plant is limited to RMI authorized personnel only, by means of 24 hour-a-day security guards.

Therefore, under the current scenario, the only population which may be potentially exposed to site soils is the industrial worker population associated with the RMI Sodium Plant. Potential soil exposure routes that will be evaluated for the industrial worker population include dermal contact, incidental ingestion, and inhalation of particulates.

A2.1.2 Future Scenarios

It is expected that the Sodium Plant site will remain industrial in the future; however, as requested by the USEPA (see Attachment I), possible future residential development of the site was considered. Therefore, two future scenarios for the site were considered (1) conditions remain essentially the same as the current situation (i.e., the site remains industrial), and (2) the site undergoes residential development. Therefore, under the future scenario, potential residential and industrial populations (the same industrial population evaluated for the current scenario) were

evaluated. Potential exposure routes that will be evaluated for the future residential and industrial worker populations include dermal contact, incidental ingestion, and inhalation of particulates. Potential future exposure of workers involved in any remediation activities that may take place at the site have not been evaluated due to the stringent OSHA requirements of personal protective equipment for such workers.

A2.2 QUANTIFICATION OF POTENTIAL EXPOSURES

In Section A2.1 potential receptors, exposure scenarios, and exposure routes were identified. In this section, potential exposures identified in Section A2.1 are quantified. For each potentially exposed population, and for each relevant route of exposure, chemical-specific estimates of the magnitude, frequency, and duration of potential exposures are determined. The quantification of potential exposures is conducted in two parts (USEPA, 1989a): (1) the estimation of exposure concentrations in various environmental media which are expected to be contacted over the exposure period; and (2) the calculation of "intakes" or normalized exposure estimates which describe the mass of a constituent expected to be in a contact with the human body per unit body weight, per unit time (in units of mg/kg-day).

The 95th percent upper confidence limit on the arithmetic averages (lognormal) of site constituents presented earlier in Section A2.0 were utilized as the exposure concentrations. Chemical-specific intakes are generally calculated using equations which may include variables such as: exposure concentration, contact rate, exposure frequency, exposure duration, body weight, and exposure averaging time. Other variables specific to a particular exposure route may also be included in the intake equations. The values used for some of the variables in the intake equations are determined on a site-specific basis in order to accurately reflect the relevant site conditions and characteristics of a given potentially exposed population. Values used for other variables may be based on: conservative assumptions; "standard" values typically used in the risk assessment process (e.g., adult body weight of 70 kg); or other sources of information. Once intakes have been estimated for the relevant potentially exposed populations they will be used later in the Risk Characterization (see Section A4.0), along with relevant toxicity values generated during the Toxicity Assessment (see Section A3.0), to estimate potential risks posed by the site under baseline (i.e., no action) conditions. The remainder of this section

will focus on the estimation of intakes for the potential exposure routes which are identified for quantification.

Intakes for each of the exposure routes were estimated by use of the intake equations given in the current federal risk assessment guidance (USEPA, 1989a). The intake equations are presented in Table A2-2. The intakes calculated with the equations presented in Table A2-2 are expressed as the amount of chemical at the exchange boundary of the body (e.g., GI tract, lungs) and available for absorption for the ingestion pathways. Because specific values from the USEPA are not currently available or widely accepted for the dermal exposure route, dermal absorption factors from Ohio EPA guidance (Ohio, 1993) have been applied for assessing potential dermal exposure to site constituents in soil.

Variables used in the intake equations are briefly described in the paragraphs below. Specific exposure parameter values used to quantify intakes are presented in Table A2-3 for each receptor population and exposure route.

Exposure Concentration (CS or CA). The concentration term in the intake equation (for soil or air, respectively) is the exposure point concentration, or that amount of a constituent which is expected to be contacted over the exposure period. Exposure concentrations are based on measured data, with the exception of air, for which a model was utilized to estimate concentrations (see Attachment II). The USEPA recommends using the 95th UCLs on the arithmetic mean for this variable (USEPA, 1989a). These limits were calculated as described earlier in Section A2.0, and were previously summarized in Table A2-1. Maximum concentrations were used to represent constituent concentrations when 95th percent limits exceeded the maximum concentration measured.

Body Weight (BW). A body weight of 70 kg is the standard body weight for adults, as recommended in the current federal risk assessment guidance (USEPA, 1989a).

Averaging Time (AT). The averaging time depends on the type of toxic effect being assessed. When evaluating longer-term exposure to noncarcinogens, intakes are calculated by averaging intakes over the period of exposure (i.e., exposure duration, ED). For carcinogens, intakes are calculated by prorating the total cumulative dose over a lifetime (i.e., chronic daily intakes, also called lifetime

TABLE A2-2

SUMMARY OF INTAKE EQUATIONS[a]

1. POTENTIAL DERMAL CONTACT WITH CONSTITUENTS IN SOIL:

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Constituent Concentration in Soil (mg/kg)
CF = Conversion Factor (10^{-6} kg/mg)
SA = Skin Surface Area Available for Contact (cm^2/day)
AF = Soil to Skin Adherence Factor (mg/cm^2)
ABS = Absorption Factor (unitless)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days)

2. POTENTIAL INCIDENTAL INGESTION OF CONSTITUENTS IN SOIL:

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Constituent Concentration in Soil (mg/kg)
IR = Ingestion Rate (mg/day)
CF = Conversion Factor (10^{-6} kg/mg)
FI = Fraction Ingested from Source (unitless)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (days)

TABLE A2-2 (Continued)

SUMMARY OF INTAKE EQUATIONS[a]

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3. POTENTIAL INHALATION OF AIRBORNE PARTICULATES FROM SOIL:

$$\text{Intake (mg/kg-day)} = \frac{\text{CA x IR x ET x EF x ED}}{\text{BW x AT}}$$

CA = Constituent Concentration in Air (mg/m^3)[b]

(Note: $CA = CS\left(\frac{1}{PEF}\right)$

IR = Inhalation Rate (m^3/hour)

ET = Exposure Time (hours/day)

EF = Exposure Frequency (days/year)

ED = Exposure Duration (years)

BW = Body Weight (kg)

AT = Averaging Time (days)

PEF = Particulate Emission Factor (m^3/kg)

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[a]Source: USEPA (1989a).

[b]Concentrations in surficial soils are converted to concentrations in air through the use of a particulate emission factor (PEF) (USEPA, 1991b). See Attachment II.

TABLE A2-3

EXPOSURE PARAMETERS FOR POTENTIAL SOIL EXPOSURE ROUTES

RMI SODIUM PLANT
ASHTABULA, OHIO

Exposure Parameters (units)	Dermal Contact[a]		Incidental Ingestion[a]		Inhalation[a]	
	Current Industrial Worker	Future Residential Adult	Current Industrial Worker	Future Residential Adult	Current Industrial Worker	Future Residential Adult
C[b]	UCL (mg/kg)	UCL (mg/kg)	UCL (mg/kg)	UCL (mg/kg)	UCL (mg/m^3)	UCL (mg/m^3)
CF (kg/mg)	10^{-6}	10^{-6}	10^{-6}	10^{-6}	--[c]	--
SA (cm^2/day)	5,800	5,800	--	--	--	--
IR (m^3/hr)	--	--	--	--	0.83	0.83
ET (hours/day)	--	--	--	--	8	24
IR (mg/day)	--	--	50	100	--	--
FI (unitless)	--	--	1.0	1.0	--	--
AF (mg/cm^2)	1.0	1.0	--	--	--	--
ABS (unitless)						
Inorganics	1 percent	1 percent	--	--	--	--
EF (days/year)	250	350	250	350	250	350
ED (years)	25	30	25	30	25	30
BW (kg)	70	70	70	70	70	70
AT (days)						
Carcinogens	25,550	25,550	25,550	25,550	25,550	25,550
Noncarcinogens	9,125	10,950	9,125	10,950	9,125	10,950

[a]The equations used to calculate intakes and the definition of the exposure parameters are presented in Table A2-2.
[b]The chemical-specific 95th percent upper confidence limit (UCL) is used as the concentration term, unless it exceeds the maximum detection. If that occurs, the maximum detection is used as the concentration term (see Table A2-1).
[c]Dashes (--) indicate that the exposure parameter is not applicable to the specified exposure route.

average daily intake). This distinction relates to the currently held scientific opinion that the mechanism of action for potential carcinogenic and chronic toxic (noncarcinogenic) effects is different. The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime (USEPA, 1989a).

Absorption Factor (ABS). Absorption factors (used when assessing potential exposures by dermal contact with constituents in soil) result in an estimation of the absorbed dose rather than administered dose (i.e., the amount of chemical in contact with the skin). Absorption factors are used to reflect the desorption of a chemical from soil and the absorption of a chemical across the skin and into the bloodstream. As previously discussed, there are no widely accepted factors in the current federal guidance, therefore dermal absorption factors were obtained from current Ohio EPA guidance: 1.0 percent for inorganics (Ohio, 1993).

Soil to Skin Adherence Factor (AF). The AF estimates the amount of soil which adheres to skin. Federal dermal exposure guidance (USEPA, 1992b) recommends a default upper value of 1 mg/cm^2 to represent the soil to skin adherence rate.

Ingestion Rate (IR). Ingestion rate is used to estimate that amount of soil ingested when assessing potential exposures by ingestion. The incidental soil ingestion rate for the industrial worker was assumed as 50 mg/day which represents adult soil ingestion in the work place (USEPA, 1991a). An ingestion rate of 100 mg/day was assumed for the residential population (USEPA, 1989a).

Inhalation Rate (IR). Inhalation rate is used to estimate the amount of air inhaled when assessing potential exposures by inhalation of particulates from soil. The inhalation rate for inhalation from exposures to soil was assumed as 0.83 m^3/hr, which represents an adult inhalation rate (USEPA, 1989a).

Fraction Ingested (FI). The FI is used to account for the fraction of ingested material that is presumed to be contaminated. For soil at the project site, an FI of 1.0 was used, which conservatively assumes that all soil incidentally ingested contains site constituents of interest.

Skin Surface Area Available for Contact (SA). To estimate potential exposures through dermal contact with soil, an SA must be assumed. Both 95th and 50th percentile body part-specific surface areas are available, but it is recommended that the 50th percentile be used (USEPA, 1989a). The dermal guidance document, *Dermal Exposure Assessment: Principles and Applications*, recommends the use of 25 percent of the total body surface area to represent SA for soil contact scenarios (USEPA, 1992b). Twenty-five percent of an adult body total surface area was assumed, resulting in an SA of 5,800 cm^2 (USEPA, 1992b).

Exposure Frequency (EF) and Exposure Duration (ED). Exposure frequency and duration are used to estimate the total time of exposure. The EFs and EDs for the various populations which were determined to have potential exposures at the site are as follows:

- **Industrial Worker Population:** An EF of 250 days/year was used to represent the industrial worker population, based on the assumption that an industrial worker would work 5 days/week for 50 weeks/year at the same location (USEPA, 1991a). The ED was assumed to be 25 years to represent the USEPA's default occupational exposure duration (USEPA, 1991a), which is based on the assumption that one individual works at the same location for 25 years.

- **Residential Population:** An EF of 350 days per year was assumed for the residential population adult, based on the USEPA's default residential exposure frequency (USEPA, 1991a). An ED of 30 years was assumed to represent the USEPA's default residential exposure duration of 30 years (USEPA, 1991a).

Exposure Time (ET). ET (hours/day) is used in the inhalation intake equation. The ET used for the industrial worker was 8 hours/day based on the conservative assumption that a worker would spend the full work day out-of-doors. The ET for the residential population was 24 hours/day as specified in the current Ohio EPA guidance (Ohio, 1993).

A2.3 SUMMARY OF INTAKES

Summaries of the estimated intakes of site constituents for populations described earlier in Section A2.1 using the constituent concentrations, intake equations, and exposure assumptions discussed earlier in this section are presented in Attachment IV.

A3.0 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh available evidence regarding the potential of site constituents to cause adverse effects in exposed individuals, and to provide, where possible, an estimate of the relationship between the extent of exposure to a constituent and the increased likelihood and/or severity of adverse effects in humans (USEPA, 1989a).

Toxicity assessments are generally accomplished in two steps: hazard identification and dose-response assessment. Hazard identification is the process of determining whether exposure to a constituent can cause an increase in the incidence of an adverse health effect (e.g., cancer), and whether the effect is likely to occur in humans. The dose-response evaluation is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the constituent and the adverse health effects in an exposed population. From this quantitative dose-response relationship, toxicity values (further discussed below) may be derived and further used to estimate the incidence of adverse effects as a function of potential human exposure to the constituent (USEPA, 1989a). These toxicity values are used later in the risk characterization (see Section A4.0) step of the baseline risk assessment process to quantify potential human exposures to site constituents.

A3.1 SOURCES OF TOXICITY INFORMATION

Although the toxicity assessment is an integral component of the baseline risk assessment process, the amount and type of toxicological information available are limited in most cases (USEPA, 1989a). The USEPA has performed the toxicity assessment step for numerous chemicals and has made available the resulting toxicity information and toxicity values through its on-line toxicity database, the Integrated Risk Information System (IRIS). IRIS was originally developed to make chemical-specific risk information readily available to the USEPA and state agencies involved in risk assessments, and to promote consistency in the performance of risk assessments and subsequent risk management decisions. The information contained in Section I (Chronic Health Hazard Assessment for Noncarcinogenic Effects) and Section II (Carcinogenicity Assessment for Lifetime Exposure) of the IRIS chemical files represents a consensus judgment of USEPA's Reference

Dose (RfD) Work Group or Carcinogen Risk Assessment Verification Endeavor (CRAVE) Work Group, respectively. These two Agency-wide Work Groups include scientists from USEPA's program offices (e.g., hazardous waste, air, pesticides) and the Office of Research and Development. Individual USEPA offices have conducted comprehensive scientific reviews of the literature available on particular chemicals, and have performed the hazard evaluation and dose-response assessment. These assessments have been summarized for IRIS and reviewed and revised by the appropriate Work Group. As new information becomes available, these Work Groups re-evaluate their work and revise IRIS files accordingly. Because the toxicity information is constantly being updated, IRIS is currently only available on-line. As of April 1988, the IRIS database was made available to the public, and all USEPA staff, USEPA contractors, and PRPs (or their consultants) are expected to use IRIS as the primary source of toxicity information in performing risk assessments (*Federal Register*, 1988).

Second to IRIS, the USEPA recommends that the Health Effects Assessment Summary Tables (HEASTs) be consulted. Formerly called "The Quarterly" and associated references, HEASTs are tabular presentations of toxicity information and values for chemicals for which Health Effects Assessments (HEAs), Health and Environmental Effects Documents (HEEDs), Health and Environmental Effects Profiles (HEEPs), Health Assessment Documents (HADs), or Ambient Air Quality Criteria Documents (AAQCDs) have been prepared. The HEASTs summarize interim (pending IRIS verification) reference doses (RfDs) for noncarcinogens and slope factors (SFs) for potential carcinogens, as well as other toxicity information for specific chemicals. Therefore, the HEASTs are especially helpful when verified information for a chemical is pending Work Group concurrence on the final database file and the toxicity values are not yet available in the IRIS database. Currently, the HEAST is to be issued each year as an annual edition with quarterly supplements. Each quarterly supplement will incorporate all information in the previous supplement and therefore replace the previous supplement. Information in the supplements will supersede the information in the annual update. The latest available HEAST at the time of this investigation is the March 1994 HEAST Annual Update (USEPA, 1994a).

Toxicity values are derived separately for potential carcinogens and noncarcinogens, and verified values are currently only available for the inhalation and ingestion

routes, for chronic exposures (USEPA, 1989a). The USEPA has values available for a selected list of hazardous chemicals in IRIS and is constantly updating the list and the values. Therefore, consistent with USEPA's risk assessment guidance (USEPA, 1989a), for the purposes of quantifying potential baseline risks associated with the site, if RfD or SF values were not available at the time of the investigation (or able to be derived) either from IRIS (as of August 1994) or the most recent HEAST (USEPA, 1994a), potential risks will not be quantified in the Risk Characterization (Section A4.0).

A3.2 TOXICITY VALUES FOR NONCARCINOGENIC EFFECTS

As mentioned above, the types of toxicity values for noncarcinogenic effects are the chronic reference doses (RfDs, formerly called ADIs or AICs). The chronic RfD is an estimate of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime, usually in units of mg/kg-day. The greater the value of the RfD, the less toxic the chemical; doses that are less than the RfD are not likely to be associated with adverse health effects. Usually, as the frequency of exposures exceeding the RfD increases, and as the size of the excess increases, the probability increases that adverse health effects may be expected in a human population. RfDs are usually determined from laboratory studies on animals, using a lowest-observed-adverse-effect-level (LOAEL) or a no-observed-adverse-effect-level (NOAEL), divided by appropriate uncertainty factors and modifying factors to account for differences in human and animal sensitivities, etc. Noncarcinogens are usually assumed to have a "threshold," i.e., a level or dose below which no adverse or toxic effects will occur. Carcinogens, as evaluated by USEPA dose-response methods, are assumed to have no such threshold. Currently, RfDs for selected chemicals may be available for two routes of exposure: ingestion and inhalation. It should be noted that noncarcinogenic effects, carcinogenic effects, or both types of effects may be associated with a single constituent.

A3.3 TOXICITY VALUES FOR POTENTIAL CARCINOGENIC EFFECTS

The carcinogenicity of a given potential carcinogen is generally described by a slope factor (SF), in units of $(mg/kg\text{-}day)^{-1}$. Slope factors are derived for chronic or lifetime exposures. The higher the SF, the more potent is a carcinogen and the more

likely the probability that a given concentration of a chemical may result in the incidence of cancer. Currently, SFs for selected chemicals may be available for two routes of exposure: ingestion and inhalation. Slope factors are not available for all potential carcinogens; also, an inhalation value and/or an ingestion value (or neither), may be available. The cancer SF is usually obtained from animal studies, and is the upper 95th percent confidence limit of the slope of a dose-response curve generated using conservative models and assumptions (USEPA, 1989a).

In assessing the carcinogenic potential of a constituent, the USEPA classifies the constituent into one of the following classes, according to the "weight of evidence" from epidemiological studies and/or animal studies:

Class A Human Carcinogen (sufficient evidence of carcinogenicity in humans);

Class B Probable Human Carcinogen (B1--limited evidence of carcinogenicity in humans; B2--sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans);

Class C Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data);

Class D Not Classifiable as to Human Carcinogenicity (inadequate or no evidence); and

Class E Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies).

Quantitative carcinogenic risk assessments are performed for chemicals in Groups A and B, and on a case-by-case basis for chemicals in Group C. Quantitative carcinogenic risk assessments are not performed for chemicals in Groups D or E (USEPA, 1989a).

Another quantitative form of carcinogenic potential occasionally given instead of a SF is a "unit cancer risk" value. The unit cancer risk is route-specific (i.e., inhalation or ingestion), and is expressed as the amount of risk associated with a

given constituent per concentration unit in air or water (e.g., risk per $\mu g/L$ of water). A SF may be approximated for chemicals for which no slope factors are provided from the unit risk values by using standard intake assumptions (e.g., ingestion of 2 liters of water/day) and solving for the slope factor in the following equations:

Risk per $\mu g/m^3$ (air) =

$$\text{Slope Factor}_{(mg/kg\text{-}d)^{-1}} \times \frac{1}{70\ kg} \times 20\ m^3/day \times 10^{-3}\ mg/\mu g$$

Risk per $\mu g/L$ (water) =

$$\text{Slope Factor}_{(mg/kg\text{-}d)^{-1}} \times \frac{1}{70\ kg} \times 2\ L/day \times 10^{-3}\ mg/\mu g$$

As further discussed in Section A4.0, in the baseline risk assessment potential risks from exposure to site constituents are estimated by using these toxicity values along with measured concentrations of the site constituents in relevant site media. The measured concentrations of the constituents are used with various intake factors (e.g., rate of ingestion) and the toxicity values to estimate potential human health risks. For carcinogens, the intake values are then multiplied by the appropriate SFs to estimate the potential frequency of cancer risks (e.g., 1 in 100,000 or 1×10^{-5} risk). For noncarcinogens, the intake values are expressed as a ratio with the appropriate RfD value.

A3.4 AVAILABLE TOXICITY VALUES FOR SITE CONSTITUENTS

The latest available SFs and RfDs for inhalation and oral exposure routes for each of the site constituents are presented in following sections. Complete toxicity profiles for each of the constituents of interest which were on file in IRIS (as of August 1994) are provided in Attachment III.

A3.4.1 Arsenic

In the USEPA's method of assessing carcinogenic potential, arsenic is in Class A, human carcinogen. The latest available IRIS database does not give an oral SF for

arsenic, but is does give a unit risk of 5×10^{-5} $(\mu g/L)^{-1}$. Using the unit risk equation for water (see Section 3.3) an oral SF of 1.8 $(mg/kg\text{-}day)^{-1}$ was estimated. An inhalation SF for arsenic for was not available in the latest IRIS database, however the latest HEAST lists had an inhalation SF of 50 $(mg/kg\text{-}day)^{-1}$.

The latest available IRIS database lists an oral RfD for arsenic of 0.0003 mg/kg-day. No inhalation RfD was available for arsenic from the latest available IRIS database or from HEAST.

A3.4.2 Cadmium

In the USEPA's method of assessing carcinogenic potential, cadmium is in Class B1, probable human carcinogenic with limited evidence of carcinogenicity in humans. However, no oral SF was available in the latest IRIS database or in HEAST. IRIS did list an inhalation unit risk for cadmium of 1.8×10^{-3} $(\mu g/m^3)^{-1}$. Using the unit risk equation for air (see Section 3.3) an inhalation SF of 6.3 $(mg/kg\text{-}day)^{-1}$ was estimated.

In the latest available IRIS database, cadmium has one oral RfD for intake via water (0.0005 mg/kg-day) and another value for intake via food (0.001 mg/kg-day). Since soil is the medium of interest, the oral RfD for food was used in all risk calculations. No inhalation RfD was available for cadmium in the latest IRIS database or in HEAST.

A3.4.3 Lead

In the USEPA's method of assessing carcinogenic potential, lead is in Class B2 which means that it is a probable human carcinogen with sufficient evidence of carcinogenicity in animals and inadequate or lack of evidence in humans. However, the USEPA currently cautions against quantifiying risks for lead and no SFs or RfDs are available in the latest IRIS database or in HEAST.

The USEPA has issued the "Revised Interim Soil Lead Guidance for CERCLA and RCRA Corrective Action Facilities" (USEPA, 1994b). This guidance recommends a screening level of 400 ppm for lead in soil for residential land use. This residential screening level for lead was calculated with the USEPA's revised lead model, the

Integrated Exposure Uptake Biokinetic Model (IEUBK). Per the July 28, 1994 meeting with the USEPA, the 400 ppm level for lead is used in this risk assessment as being protective of potential human exposures.

A3.5 MODIFIED TOXICITY VALUES FOR EXPOSURE ROUTES

The toxicity data previously presented for each constituent are relevant only to the oral and inhalation exposure routes. As previously discussed in detail in Section A2.1, there is a potential for human receptors to be exposed to site constituents via other exposure routes (e.g., dermal contact and inhalation of particulates).

Although intake equations are now available in the most recent federal risk assessment guidance (USEPA, 1989a) for various exposure routes besides ingestion, insufficient exposure data exist for some of the intake variables, and/or insufficient toxicity data exist to evaluate some exposure routes other than ingestion with any degree of confidence. For example, for the dermal contact exposure route, the intake equation in the current federal guidance (USEPA, 1989a) requires that an "absorption factor" (for constituents in soil) be used. The use of these values results in an estimate of absorbed dose, rather than administered dose, or the amount of chemical that comes in contact with the skin. Chemical-specific, USEPA-recommended values for these factors are not currently available or widely accepted. Therefore, as was discussed in Section A2.2, a dermal absorption factor from Ohio EPA guidance (1.0 percent for inorganics) has been applied in the quantification of risks associated with soils which are presented in Section A4.0 (Ohio EPA, 1993). Similarly, there are no toxicity values specific to the dermal exposure route. For the dermal exposure risk estimates for each area, oral toxicity factors were used, and 100 percent absorption was assumed.

Likewise, inhalation toxicity values currently available in IRIS are based upon exposure to the constituent in the vapor phase, not as a particulate. No method for converting vapor phase toxicity values to particulate toxicity values is given in the current federal guidance (USEPA, 1989a). Therefore, in the inhalation pathways presented in Section A4.0, the inhalation toxicity values are used for particulate emissions.

Only chronic toxicity values are currently available and verified in USEPA's IRIS database for most constituents of interest (USEPA, 1989a). Therefore, the quantification of exposures of less than a chronic duration (e.g., subchronic) would be based on assumptions predicated upon very little USEPA-approved data. Therefore, only chronic exposures are addressed in this risk assessment.

A4.0 RISK CHARACTERIZATION

This section describes the final step of the baseline risk assessment process, the Risk Characterization. In this step, the exposure assessment information previously presented in Section A2.0 and the toxicity assessment information previously given in Section A3.0 are summarized and integrated into quantitative expressions of potential risk to human health presented by the site. Uncertainties associated with the estimation of potential human health risks are also presented.

To characterize potential carcinogenic effects, probabilities that individuals in an exposed population may develop cancer over a lifetime of exposure are estimated from projected intakes (discussed in Section A2.2 and presented in Attachment IV) and chemical-specific toxicity information. To characterize potential chronic noncarcinogenic effects, comparisons are also made between projected intakes and different types of chemical-specific toxicity values. Risk characterization serves as the bridge between risk assessment and risk management, and is therefore a key step in RFI/CMS decision-making. The results of the risk characterization will be used in the CMS to help determine whether remedial actions should be taken at the site, and in which areas. The result of quantifying potential risks in the baseline risk assessment is not a characterization of absolute risk, and should not be interpreted as such (USEPA, 1989a). Rather, the baseline risk results should be interpreted as a quantitative means for making potential future remedial action decisions.

In the following sections, the most recent federal risk characterization methodology (USEPA, 1989a) is described. There are separate discussions for potential carcinogenic and noncarcinogenic chronic effects because the biological mechanisms and the methodology used to evaluate these effects differ. Potential risks from individual pathways (e.g., dermal absorption from soils) and potential risks presented by combinations of multiple pathways (e.g., incidental ingestion and dermal absorption of soils and inhalation of particulates from soil) are also presented.

The following sections present the methodology for estimating potential risks, summaries of estimated potential site risks, a summary and comparison to acceptable risk levels, and an analysis of uncertainties.

A4.1 METHODOLOGY FOR ESTIMATION OF POTENTIAL RISKS

This section describes steps for quantifying potential future risks for both carcinogenic and noncarcinogenic chronic effects to be applied to each of the potential exposure scenarios identified in Section A2.1. This is followed in Section A4.2 by a presentation of the estimates of potential human health risks for the areas of interest.

Individual Risk Estimates

Carcinogens. For potential human carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to potential carcinogen(s), i.e., incremental or excess individual lifetime cancer risk (e.g., 1×10^{-5} or 1 in 100,000).

Slope factors (SF) were discussed in detail and presented in Section A3.3. In combination with estimated chronic daily intakes (CDIs, previously discussed in Section A2.2 and presented in Attachment IV), a SF for a given constituent averaged over a lifetime of exposure results in an expression of the potential incremental risk of an individual developing cancer in a lifetime from that constituent. Because relatively low intakes (compared to those experienced by test animals) are expected to result from environmental exposures, it is generally assumed by USEPA that the dose-response relationship will be linear in the low-dose portion of the multistage model dose-response curve (USEPA, 1989a). Under this assumption, the SF is a constant, and risk will be directly related (i.e., proportional) to intake. Thus, the linear form of the carcinogenic risk equation given below is used for chemical-specific risks:

$$\text{Chemical-Specific CR} = \text{CDI} \times \text{SF}$$

where:

CR = chemical-specific carcinogenic risk, a unitless probability (e.g., 2×10^{-5}) of an individual developing cancer;
CDI = chronic daily intake averaged over 70 years (mg/kg-day); and
SF = slope factor $(mg/kg\text{-}day)^{-1}$

Because the SF usually reflects the upper 95th percent confidence limit of the probability of response based on experimental animal data used in the multistage dose model, the use of the SFs results in a carcinogenic risk estimate which is an upper-bound estimate independent of exposure assumptions (i.e., assumptions affecting the CDI), which may also be a source of inherent conservatism in the risk estimate. This means that the "true" risk will most likely not exceed the risk estimate derived through use of this model, and will most likely be less than that predicted with the model.

Noncarcinogens. The measure used to describe the potential for noncarcinogenic effects to occur in an individual is <u>not</u> expressed as the probability of an individual experiencing an adverse effect. At the present time, the USEPA does not use a probabilistic approach to estimating the potential for noncarcinogenic chronic health effects. Instead, the potential for noncarcinogenic chronic effects is evaluated by comparing an exposure level (i.e., the CDI) over a specified time period with a reference dose value (RfD). This ratio of exposure to toxicity is called a "hazard quotient", defined below (USEPA, 1989a):

Chemical-Specific HQ = CDI/RfD

where:

HQ = chemical-specific noncarcinogenic hazard quotient;
CDI = chronic daily intake (mg/kg-day); and
RfD = reference dose (mg/kg-day)

The noncarcinogenic HQ assumes that the level of exposure associated with the RfD is below that which is associated with adverse health effects (including sensitive populations). If the CDI exceeds this threshold (i.e., if CDI/RfD exceeds unity), there

may be a potential for noncarcinogenic chronic effects. As a rule, the greater the value of CDI/RfD above unity, the greater the level of concern. However, the ratios of CDI/RfD are not statistical probabilities (i.e., a ratio of 0.001 does not mean that there is a one in one thousand chance of the effect occurring). Further, it is important to emphasize that the level of concern does not increase linearly as the RfD is approached or exceeded, because the values of RfDs do not have equal degrees of certainty, and are not based on the same severity of toxic effects. Thus, the slopes of the dose-response curve in excess of the RfD can range widely depending on the substance.

Risk Estimates for Multiple Constituents and Pathways

As discussed in Section A2.0, three constituents have been identified in soil in the five areas of interest (collectively) at the RMI Sodium Plant. Estimates of potential risk or hazard generated by considering one constituent at a time may underestimate the risks associated with simultaneous exposures to several constituents. Therefore, the USEPA recommends assessing the overall potential for carcinogenic and noncarcinogenic chronic effects posed by multiple constituents simultaneously for a given exposure route. Also, exposures to several constituents by more than one exposure pathway may need to be considered. Although the calculation procedures differ for carcinogenic and noncarcinogenic chronic effects, both sets of procedures assume dose additivity. As described in Sections A2.1, both the industrial and residential populations considered during this baseline risk assessment may have the potential to be exposed via multiple exposure routes (e.g., industrial worker populations may be potentially exposed to constituents in soil through incidental ingestion, inhalation, and dermal contact exposure routes).

Carcinogens. The equation for estimating the incremental individual lifetime carcinogenic risks for simultaneous exposure to more than one carcinogenic constituent (and perhaps, via multiple exposure routes) is given below (USEPA, 1989a):

$$\text{Total CR} = \Sigma \text{CR}_i$$

where:

Total CR = the total carcinogenic risk, expressed as a unitless probability; and

CR_i = chemical-specific $risk_i$, the risk estimate for the i^{th} substance

The use of this method assumes that there is independence of action by the compounds involved, (i.e., there are no synergistic or antagonistic chemical interactions), and that all chemicals produce the same effect (i.e., cancer).

USEPA's "acceptable" (by policy) incremental carcinogenic risk range cited in the current National Contingency Plan (NCP, *Federal Register*, 1990a) is 10^{-6} to 10^{-4} (or one in one million to one in ten thousand). In addition, the NCP specifies that the lower limit of 10^{-6} shall be the "point of departure" for potential carcinogens in determining remedial alternatives, indicating the USEPA's preference for more protective remediation. For carcinogens, when an applicable standard does not exist or is not sufficiently protective due to multiple exposures or multiple contaminants, USEPA selects remedies resulting in risks that fall within a range of 10^{-6} to 10^{-4} (*Federal Register*, 1990a). USEPA indicates that a site that has a cumulative carcinogenic risk in excess of 1×10^{-4} generally warrants remedial action. However, the upper bound of the risk range (10^{-4}) is not considered a discrete line. A specific risk estimate around 10^{-4} may be considered acceptable if justified under site-specific conditions (USEPA, 1991b).

In the USEPA's proposed RCRA regulations (Subpart S, *Federal Register*, 1990b) it is stated that "action levels" for carcinogens should be estimated assuming a 1×10^{-6} target risk level for Class A and B carcinogens and action levels for Class C carcinogens should be estimated assuming a 1×10^{-5} target risk level. The proposed regulations indicate that for carcinogens, cleanup levels for RCRA sites will be established within the range of 10^{-6} to 10^{-4}, based on site-specific factors, unless another level is deemed appropriate (*Federal Register*, 1990b).

Noncarcinogens. To assess the overall potential for noncarcinogenic chronic effects posed by more than one constituent, USEPA recommends that a hazard

index (HI) approach be used in the current federal risk assessment guidance (USEPA, 1989a). This approach assumes that simultaneous exposures to more than one noncarcinogen could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of ratios of the exposures to acceptable exposures. The hazard index is equal to the sum of the chemical-specific hazard quotients per exposure pathway. When the hazard index exceeds unity (1.0), there may be concern for potential health effects. While any single constituent with an exposure level greater than the toxicity value will cause the HI to exceed unity, for multiple constituent exposures, the HI can also exceed unity even if no single chemical exposure exceeds its RfD. The equation for calculating the noncarcinogenic chronic hazard index (USEPA, 1989a) is given below:

$$HI = CDI_1/RfD_1 + CDI_2/RfD_2 + \ldots + CDI_i/RfD_i$$

where:

HI = total noncarcinogenic chronic hazard index;
CDI_i = total chronic daily intake for the i^{th} substance; and
RfD_i = reference dose for the i^{th} substance

When a constituent was identified as having both potential carcinogenic and noncarcinogenic chronic effects, as a conservative measure, both types of effects were quantified.

For noncarcinogens, the USEPA considers a hazard index "acceptable" if it is less than 1.0, because adverse effects to human populations would not be expected to occur. The USEPA indicates that a site that has a noncarcinogenic cumulative HI of greater than 1.0 generally warrants remedial action (USEPA, 1991b).

Chronic toxicity factors for potential carcinogens (SFs) and for noncarcinogenic chronic effects (RfDs) were discussed in detail in Section A3.0, along with supporting information (available IRIS summaries for each constituent of interest may be found in Attachment III).

A4.2 ESTIMATED POTENTIAL CURRENT RISKS

Chemical-specific risks associated with soil from each area of interest and the potential receptor population evaluated under the current scenario (see Section A2.1.1) were calculated and summed for the specific exposure routes (e.g., incidental ingestion of surficial soil) (detailed tables may be found in Attachment IV). No risks were calculated for Area D since lead was the only constituent of interest in this area. As discussed in Section A3.4.3, no EPA approved toxicity values (SFs or RfDs) are available for lead. However, USEPA has recently issued revised soil lead guidance which can be used to assess potential health effects for lead in soils (see Section A3.4.3).

For the current scenario, one potential receptor population, the industrial worker, was evaluated for potential exposure to soil from each of the five areas of interest (B, C, D, F, and G). Table A4-1 presents a summary of all current risk estimates associated with soil, by area.

Exposure concentrations of site constituents and potentially relevant exposure scenarios were described in detail in Section A2.1. Chronic daily intakes for the constituents of interest were discussed in Section A2.3 and presented in Attachment IV. Using this information and the current USEPA methods (USEPA, 1989a) for estimating potential risks (which were described above in Section A4.1), area-specific risks were estimated for the industrial worker population. It should be noted that risk estimates for Areas B and C were evaluated separately (Area B and Area C) as well as combined (Areas B and C) because this was how the RFI considered the areas due to their proximity to one another.

The total noncarcinogenic hazard indices for the current scenario ranged from 0.077 (Area F) to 0.85 (Area B and Areas B and C combined). The highest current hazard index (0.85) was driven by both dermal contact and incidental ingestion exposure routes, of which cadmium was the primary risk contributor. The hazard index for background soil was 0.066 (see Table A4-1).

For the current scenario, the total carcinogenic risk estimates ranged from 1.5×10^{-5} (Area F) to 1.6×10^{-5} (Areas B, C, Areas B and C combined, and G). Identical carcinogenic risk estimates for these areas are the result of similar

TABLE A4-1

SUMMARY OF POTENTIAL CURRENT RISK ESTIMATES FOR SOIL FOR THE INDUSTRIAL WORKER POPULATION[a]

RMI SODIUM PLANT
ASHTABULA, OHIO

Area	Exposure Route(s)	Noncarcinogens			Carcinogens		
		Estimated Hazard Index	Percent of Constituent Contribution		Estimated Carcinogenic Risk	Percent of Constituent Contribution	
			Arsenic	Cadmium		Arsenic	Cadmium
I. Area B - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.45	9.6%	91%	8.6×10^{-6}	100%	--
	Incidental Ingestion	0.40	10%	90%	7.4×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	1.5×10^{-8}	21%	80%
	Total:	0.85			1.6×10^{-5}		
II. Area C - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.043	100%	--	8.5×10^{-6}	100%	--
	Incidental Ingestion	0.037	100%	--	7.4×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	4.4×10^{-9}	100%	--
	Total:	0.080			1.6×10^{-5}		
III. Areas B and C - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.45	9.6%	91%	8.5×10^{-6}	100%	--
	Incidental Ingestion	0.40	9.3%	90%	7.4×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	2.6×10^{-8}	21%	77%
	Total:	0.85			1.6×10^{-5}		

TABLE A4-1 (Continued)

SUMMARY OF POTENTIAL CURRENT RISK ESTIMATES FOR SOIL FOR THE INDUSTRIAL WORKER POPULATION[a]

RMI SODIUM PLANT
ASHTABULA, OHIO

Area	Exposure Route(s)	Noncarcinogens: Estimated Hazard Index	Noncarcinogens: Percent of Constituent Contribution — Arsenic	Noncarcinogens: Percent of Constituent Contribution — Cadmium	Carcinogens: Estimated Carcinogenic Risk	Carcinogens: Percent of Constituent Contribution — Arsenic	Carcinogens: Percent of Constituent Contribution — Cadmium
IV. Area F - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.040	100%	--	8.1×10^{-6}	100%	--
	Incidental Ingestion	0.037	100%	--	6.8×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	3.7×10^{-9}	100%	--
	Total:	0.077			1.5×10^{-5}		
V. Area G - Surficial Soils (0 - 4 inches) and Near Subsurface Soils (0.5 - 3.3 feet)							
	Dermal Contact	0.14	31%	70%	8.6×10^{-6}	100%	--
	Incidental Ingestion	0.12	31%	71%	7.4×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	8.5×10^{-9}	52%	48%
	Total:	0.26			1.6×10^{-5}		
VI. Background - Surficial Soils (0 - 4 inches) and Subsurface Soils (1 - 57 feet)							
	Dermal Contact	0.035	94%	4.9%	6.5×10^{-6}	100%	--
	Incidental Ingestion	0.031	94%	4.8%	5.6×10^{-6}	100%	--
	Inhalation of Particulates	--	--	--	4.2×10^{-9}	98%	2.1%
	Total:	0.066			1.2×10^{-5}		

[a]All chemical-specific risks estimates are presented in Attachment IV. Total risk estimates are rounded to two significant digits.

exposure point concentrations for arsenic among these areas, as shown in Table A2-1. The highest current carcinogenic risk estimates (1.6×10^{-5}) were principally driven by both the dermal contact and incidental ingestion exposure routes, of which arsenic was the sole risk contributor. The total carcinogenic risk estimate for background soil was 1.2×10^{-5} (see Table A4-1).

A4.3 ESTIMATED POTENTIAL FUTURE RISKS

Potential chemical-specific risks associated with the constituents of interest in soil from each area evaluated under the future scenarios (see Section A2.1.2) were calculated and summed for the specific exposure routes (detailed tables may be found in Attachment IV). No risks were calculated for Area D since lead was the only constituent of interest in this area. As discussed in Section A3.4.3, no toxicity values (SFs or RfDs) are available for lead.

In addition to the current industrial water population, one receptor population (residential) for soil was considered relevant. Table A4-2 presents a summary of risk estimates for a potential future residential population.

The total noncarcinogenic hazard indices for the future scenarios ranged from 0.16 (Area F) to 1.7 (Area B, and Areas B and C combined). The highest noncarcinogenic hazard index (1.7) was driven by the incidental ingestion and dermal contact exposure routes, of which cadmium was the primary risk contributor. The hazard index for background soil was 0.13 (see Table A4-2).

For the future scenarios, total carcinogenic risk estimates ranged from 3.7×10^{-5} (Area F) to 3.9×10^{-5} (Areas B and C, Areas B and C combined, and G). Identical carcinogenic risk estimates for these areas are the result of similar exposure point concentrations for arsenic among these areas, as shown in Table A2-1. The highest total carcinogenic risk estimate (3.9×10^{-5}) was primarily driven by both dermal contact and incidental ingestion exposure routes, of which arsenic was the sole risk contributor. The total carcinogenic risk estimate for background soil was 2.9×10^{-5} (see Table A4-2).

TABLE A4-2

SUMMARY OF POTENTIAL FUTURE RISK ESTIMATES FOR SOIL FOR THE RESIDENTIAL ADULT POPULATION[a]

RMI SODIUM PLANT
ASHTABULA, OHIO

Area	Exposure Route(s)	Noncarcinogens			Carcinogens		
		Estimated Hazard Index	Percent of Constituent Contribution		Estimated Carcinogenic Risk	Percent of Constituent Contribution	
			Arsenic	Cadmium		Arsenic	Cadmium
I. Area B - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.64	9.8%	91%	1.4×10^{-5}	100%	--
	Incidental Ingestion	1.1	10%	91%	2.5×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	7.6×10^{-8}	21%	79%
	Total:	1.7			3.9×10^{-5}		
II. Area C - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.063	100%	--	1.4×10^{-5}	100%	--
	Incidental Ingestion	0.11	100%	--	2.5×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	2.2×10^{-8}	100%	--
	Total:	0.17			3.9×10^{-5}		
III. Areas B and C - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.64	9.4%	91%	1.4×10^{-5}	100%	--
	Incidental Ingestion	1.1	10%	91%	2.5×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	1.3×10^{-7}	21%	77%
	Total:	1.7			3.9×10^{-5}		

TABLE A4-2 (Continued)

SUMMARY OF POTENTIAL FUTURE RISK ESTIMATES FOR SOIL FOR THE RESIDENTIAL ADULT POPULATION[a]

RMI SODIUM PLANT
ASHTABULA, OHIO

Area	Exposure Route(s)	Noncarcinogens			Carcinogens		
		Estimated Hazard Index	Percent of Constituent Contribution		Estimated Carcinogenic Risk	Percent of Constituent Contribution	
			Arsenic	Cadmium		Arsenic	Cadmium
IV. Area F - Surficial Soils (0 - 4 inches)							
	Dermal Contact	0.057	100%	--	1.4×10^{-5}	100%	--
	Incidental Ingestion	0.10	100%	--	2.3×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	1.9×10^{-8}	100%	--
	Total:	0.16			3.7×10^{-5}		
V. Area G - Surficial Soils (0 - 4 inches) and Near Subsurface Soils (0.5 - 3.3 feet)							
	Dermal Contact	0.20	32%	70%	1.4×10^{-5}	100%	--
	Incidental Ingestion	0.35	31%	69%	2.5×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	4.3×10^{-8}	51%	49%
	Total:	0.55			3.9×10^{-5}		
VI. Background - Surficial Soils (0 - 4 inches) and Subsurface Soils (1 - 57 feet)							
	Dermal Contact	0.049	96%	4.9%	1.1×10^{-5}	100%	--
	Incidental Ingestion	0.084	95%	5.0%	1.8×10^{-5}	100%	--
	Inhalation of Particulates	--	--	--	2.1×10^{-8}	100%	2.0%
	Total:	0.13			2.9×10^{-5}		

[a]All chemical-specific risks estimates are presented in Attachment IV. Total risk estimates are rounded to two significant digits.

A4.4 COMPARISON OF RISK ESTIMATES TO BACKGROUND RISKS

Carcinogenic risks and noncarcinogenic hazard indices were calculated and summed for the specific exposure routes for all the areas of interest as well as for background soils, collectively from all depths. For the current industrial scenario, the total carcinogenic risk estimate for background soils was 1.2×10^{-5}. This risk estimate was driven solely by arsenic. This risk estimate is very close to the maximum total carcinogenic risk for the current scenario (1.6×10^{-5}) that was estimated for Areas B, C, Areas B and C combined, and Area G (see Table A4-1).

The total noncarcinogenic hazard index calculated for the current scenario for background soil was 0.066. This hazard index was solely driven by arsenic. The maximum total noncarcinogenic hazard index for the current scenario (0.85) is higher than this background soil total hazard index (0.066) due to the higher concentrations of cadmium in soil samples collected from Area B (see Table A4-1).

For the future residential scenarios, the total carcinogenic risk estimate for background soils was 2.9×10^{-5}. This risk estimate was primarily driven by arsenic. The background risk estimate of 2.9×10^{-5} is very close to the maximum total carcinogenic risk estimated for the future scenario (3.9×10^{-5}) calculated for Areas B, C, Areas B and C combined, and Area G (see Table A4-2).

The total noncarcinogenic hazard index calculated for background soil for the future residential scenario was 0.13. This hazard index was primarily driven by arsenic. The maximum total noncarcinogenic hazard index estimated for the future scenario (1.7) is higher than the background soil total hazard index (0.13) due to the higher concentrations of cadmium in soil samples collected from Area B (see Table A4-2).

As discussed above, several of the risk estimates, including those for background soils which are remote from and unaffected by the SWMUs at the RMI site, are controlled largely by the presence of arsenic. This is not particularly surprising based upon the results of other studies of background soils concentrations in the Fields Brook drainage basin. The arsenic concentrations measured during the Sodium Plant RFI are in the range of those measured at other locations near Fields Brook. RMI has identified four possible explanations for the presence of arsenic: 1) its natural presence in soils; 2) pesticide use during previous farming in the area;

3) the nearby Elkem ferrosilicon plant air emissions; and 4) the nearby coal-burning power plant air emissions.

A4.5 SUMMARY AND COMPARISON TO ACCEPTABLE RISK LEVELS

Considering all of the total estimated carcinogenic risks for both the current and future scenarios, including risk estimates for background soil, none of the total estimated carcinogenic risks for either the current or future scenarios exceeded the upper limit of USEPA's acceptable range (1×10^{-4}). Two future noncarcinogenic hazard indices exceeded USEPA's acceptable limit of 1.0: potential residential exposure to surficial soils from Area B and potential residential exposure to surficial soils from Areas B and C combined. (Note: the combined area exceeded the limit because Area B exceeded the limit). With the exceptions of these two risk estimates, all of the remaining total noncarcinogenic hazard indices were below USEPA's acceptable level of 1.0.

As previously discussed in Section A3.4.3, there is no currently accepted toxicity value for lead, and thus risks for lead were not quantified. The USEPA agreed, therefore, to use the recently released CERCLA/RCRA lead screening level for residential soils (400 ppm) to evaluate the concentrations of lead in soil in the areas of interest at the RMI Sodium Plant. As shown in Table A2-1, the only soil sample which exceeded this value was collected from Area B, 0 to 4 inches (SS3-3, 1,140 ppm).

The risk estimates for the SWMUs should also be considered in conjunction with those calculated for the background soils. First, it is clear that the background risk estimates present the absolute lower performance bound of any possible cleanup activities at the site, and thus cleanup to a one in one million (1×10^{-6}) risk level would be impossible. Second, with the exception of the hazard indices for Area B, all of the potential risks are very close to background conditions, and corrective measures for the other SWMUs would offer only marginal enhancement of protection of human health. Finally, the only risk estimates which exceed USEPA's acceptable values are for a speculative future residential development on a long-standing industrial property, and therefore, from the perspective of protecting human health, there are no compelling reasons to undertake any sort of corrective measures for soils in SWMUs at the RMI Sodium Plant. However, even though the

only calculated risk value that exceeded allowable USEPA limits was for total noncarcinogenic hazard indices for the speculative future residential scenario (maximum hazard index of 1.7), the CMS has evaluated remedial alternatives that would lead to a reduction of potential health risks presented by the current contaminant levels found in site soils.

A4.6 ANALYSIS OF UNCERTAINTIES

An analysis of uncertainty assists in the evaluation of the level of confidence in the quantitative risk estimates for a site. The risk methods described in the current federal risk assessment guidance are not fully probabilistic approaches to estimates of risk, but conditional estimates, given a considerable number of assumptions about exposure and toxicity (e.g., risks estimated assuming a particular future land use). Thus, it is important to specify the assumptions and uncertainties inherent in the risk assessment to place the risk estimates in proper perspective (USEPA, 1989a).

Highly quantitative statistical uncertainty analysis is usually not practical nor necessary for most site risk assessments for a number of reasons, not the least of which are the resource requirements to collect and analyze site data in such a way that the results can be presented as valid probability distributions. The current federal risk assessment guidance (USEPA, 1989a) notes that risks quantified by the approach presented in the baseline risk assessment guidance have a relatively large degree of uncertainty associated with the numerical results (i.e., in the range of at least an order of magnitude or greater). Consequently, it is important to identify the key site-related variables and assumptions that contribute most to the uncertainty, rather than to precisely quantify the degree of uncertainty in the risk assessment (USEPA, 1989a). Therefore, in this section, only the assumptions and approaches which are expected to result in the greatest degree of uncertainty in the baseline risk assessment process and in its application to the areas of interest are discussed.

A4.6.1 Evaluation of Constituents and Media

The evaluation of site constituents was presented in Section A2.0. Through the comparison to background data selection process and the comparison of data to USEPA action levels conducted in the RFI (see Section 6.2 of the RFI report), a subset of constituents was selected from the range of all constituents detected in the

site media. This selection of a subset of constituents of interest at the site may potentially underestimate risk, although USEPA set action levels at very conservative (protective) values.

As discussed in Section A2.0, when the upper 95th percent confidence limit (UCL) exceeded the maximum detection for a constituent, the maximum detection was used as the exposure point concentration in the intake equations. The UCL may exceed the maximum detection when there is a small number of samples for each area, or a wide range of concentrations, both of which result in a large standard deviation. Large standard deviations were obtained for cadmium in calculating the UCLs for each area of interest. This would be expected to lead to the overestimation of risk associated with that constituent.

A4.6.2 Toxicity Factors

The use of toxicity factors, many of which are based exclusively on animal studies, leads to uncertainty in estimation of potential risks to humans because of differences in body weight, surface area, life span, metabolism, and other factors. Furthermore, all toxicity factors available are used in the risk assessment process, regardless of the associated weight of evidence. For example, there is no adjustment in risk estimates calculated using factors for a class "A" (human) carcinogen versus a class "C" (possible human) carcinogen.

The methods used to derive SFs and RfDs, as presented in IRIS and the HEAST, are inherently conservative, and tend to overestimate risks. However, toxicity factors are not available for all constituents. Lead did not have a current SF or RfD value listed in either IRIS or the latest available HEAST at the time of this investigation, but was evaluated using the most recent USEPA directive.

The lack of inhalation RfDs for all of the constituents of interest for the air pathway is a potential source of uncertainty which may lead to the underestimation of risks associated with the air pathway.

A4.6.3 Exposure Assumptions

One part of a risk assessment which contains several areas of uncertainty is the exposure assessment. Often the exposure assumptions that must be used to assist in the quantification of potential risk are speculative in nature. For the baseline risk assessment, several exposure assumptions were used that contributed to the uncertainty associated with the risk estimates.

Conservative values were utilized for many of the parameters used to determine intakes. This included such parameters as ingestion rates, body weight, etc., (see Section A2.2). In addition, the upper 95th percent confidence limits on the arithmetic average constituent concentrations assuming a lognormal distribution of data were used to determine intakes. The upper 95th percent confidence limit values are inherently conservative, and their use, in conjunction with the other conservative exposure parameters, may potentially result in the overestimation of risk associated with soil in the areas of interest.

In addition to conservative exposure values, uncertainty is also associated with the likelihood of the future scenarios that were evaluated. Although all future scenarios are speculative in nature and add some degree of uncertainty to the risk assessment, the evaluation of the future residential scenario is considered a very conservative evaluation of potential future risks.

A4.6.4 Air Concentration Modeling

The estimation of airborne concentrations from soil (see Attachment II) involved a number of assumptions which are conservative in nature. The calculation of particulate emission factors (PEF) does not take into account the possibility of the retarding effect of precipitation on the particulate emissions. For the years 1978 through 1987, Ashtabula annual rainfall ranged from 28.6 to 46.6 inches and total snowfall per year ranged from 46.5 to 56.0 inches (see Section 4.5 of the RFI report), thereby reducing potential emissions. This consideration is in addition to the conservatism built in the model used to calculate particulate emissions, and therefore the approach used most likely overestimates risks associated with the air pathway.

There are also assumptions that have been employed which may potentially **underestimate** potential risks:

- Use of upper 95th percent confidence limit on the arithmetic average values to estimate concentrations for intake calculations (5 percent probability that risks would be underestimated)

- A subset of constituents were selected from the range of constituents detected in soil (i.e., the comparisons to background soil concentrations and action levels)

In addition to those sources which may potentially overestimate or underestimate risks, there are also sources of uncertainty which have impacts to potential risks that are **unknown**. These include the following:

- The use of dermal absorption factors

- Use of default parameters in the estimation of air concentrations based on the soil media

- Use of professional judgments for potential exposure frequency and duration parameters

- The assumption of no antagonistic and no synergistic effects

On balance, it is expected that these risk estimates tend to overestimate potential risks and are, therefore, consistent with the tendencies of regulatory agencies to err on the side of caution.

A5.0 REFERENCES

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